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The ARCTURUS Laser Laboratory: Advanced Plasma-Based Acceleration and Ultrabright Beam Applications

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The ARCTURUS laser laboratory at Heinrich Heine University Düsseldorf (HHU) is undergoing a renewed phase of development, with a sharpened focus on plasma-based electron acceleration. At the heart of the facility is the ARCTURUS system, a 150 TW, multi-pulse laser capable of delivering synchronised high-power and probe pulses into a radiation-shielded experimental area. This infrastructure supports multiple beamlines, offering a flexible development platform for complex multi-stage accelerator setups and advanced diagnostics. Initial experimental campaigns have successfully demonstrated the generation of energetic electron bunches via laser wakefield acceleration (LWFA), with simultaneous characterisation of associated dosing effects on electronic components - an application directly relevant to space radiation hardness testing, but also for medical treatments of superficial cancers.

Our primary development trajectory centres on a hybrid plasma wakefield acceleration scheme, in which an LWFA-produced electron beam powers a second, beam-driven plasma wakefield accelerator (PWFA) stage. This configuration combines the compactness and synchronisation benefits of LWFA with the enhanced energy output and beam quality prospects of PWFA. We outline the current and future development plans as ARCTURUS is envisaged to serve as a versatile testbed for advancing next-generation plasma accelerator technologies aimed at high-brightness electron-bunch production and secondary radiation sources, including FEL applications

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